disturbed areas. In some populations, only a few individuals have been found off these disturbances (E. E. Neely, personal observation). Congeners grow on unstable substrates, such as scree slopes, gravel bars, shorelines, and solifluction lobes (Harris 1985). Many rare taxa in the western flora of North America and their common relatives colonize disturbed habitats (Stebbins 1980). *Braya* may inhabit unstable or disturbed areas because of an inability to compete with other species, as suggested by Griggs (1940) for other species of rare plants.

Of the three populations, Mt. Bross plants appear to be the most vigorous, perhaps because past disturbance has reduced the density or size of other plants, leaving more resources available to *Braya*. The largest plants and those with the greatest amout of reproductive output at Mt. Bross occur mostly on the margins of a rough vehicle path and on spoil banks adjacent to a ditch. The path is level, and the surface is apparently stable. At West Hoosier, the cutoff road is considerably more disturbed than the adjacent areas. Possibly the degree of disturbance on the road is greater than optimum for *Braya*, given the virtual absence of seedlings and small proportion of juveniles.

Observations of *Braya* in the Spout Lake population reinforce the importance of soil disturbance. Here it typically grows in small gravels, scree slopes, and solifluction lobes that have been demonstrated in Rocky Mountain National Park, Colorado, to move downhill at a rate of 3–4 cm $year^{-1}$ (Benedict 1970). *Braya* appears to be preadapted to unstable substrates, making it most successful where there has been some moderate level of natural or man-made disturbance.

The sizes of *Braya* populations before human intervention began is unknown, but if populations at relatively undisturbed sites such as Spout Lake are any indication, populations must have been small. In some cases human disturbance may simulate natural processes that create suitable habitat; however, drastic disturbances such as mine-related activities could greatly reduce or eliminate populations. Because *Braya* is found on calcareous soils derived from rocks such as limestone, which are often highly mineralized, it may be threatened by potential mining activities.

Acknowledgments

This research was conducted while the senior author was supported by the Colorado Field Office and the Rocky Mountain Heritage Task Force of the The Nature Conservancy, the U.S. Fish and Wildlife Service, and the Colorado Native Plant Society. The authors thank J. G. Harris, M. K. Owens, J. S. Peterson, and L. M. Shultz for critically reading the manuscript and TNC Stewardship Committee, Colorado Chapter, volunteers for assistance with data collection. C. M. Warner drafted the figure.

Literature Cited

BENEDICT, J. B. 1970. Downslope soil movement in the Colorado alpine region: rates, processes and climatic significance. Arctic Alp. Res. 2: 165–226.

BILLINGS, W. D. 1974. Arctic and alpine vegetation: plant adaptations to cold summer climates. Pages 404–443 *in* J. D. Ives and R. G. Barry, eds., Arctic and alpine environments. Metheun, London.

BRADSHAW, M. E., AND J. P. DOODY. 1978. Population studies and their relevance to nature conservation. Biol. Conserv. 14: 223–242.

CLEGG, M. T., AND A. H. D. BROWN. 1983. The founding of plant populations. Pages 216–228 *in* C. M. Schonewald-Cox, S. M. Chambers, and B. MacBryde, eds., Genetics and conservation. Benjamin-Cummings Publ. Co., Inc., London.

FAY, J. J. 1985. Endangered and threatened wildlife and plants; review of plant taxa for listing as endangered or threatened species; notice of review. Federal Register 50(188): 39526–39584.

GRELLER, A. M. 1974. Vegetation of roadcut slopes in the tundra of Rocky Mountain National Park, Colorado. Biol. Conserv. 6: 84–93.

GRIGGS, R. F. 1940. The ecology of rare plants. Bull. Torrey Bot. Club 67: 575–594.

HARMON, W. 1980. Field data summary for *B. humilis* ssp. *ventosa*. Report prepared for the Colorado Natural Areas Program, Department of Natural Resources, Denver, Colorado.

HARRIS, J. G. 1985. A revision of the genus *Braya* (Crucifereae) in North Ameria. Unpublished dissertation, University of Alberta, Edmonton.

JOHNSTON, B. 1984. Revised status report of *Braya humilis* ssp. *ventosa*. U.S. Forest Service, Region II, Denver, Colorado.

JOLLS, C. L. 1982. Plant population biology above timberline: biotic selective pressures and plant reproductive success. Pages 83–95 *in* J. C. Halfpenny, ed., Ecological studies in the Colorado alpine: a festschrift for John W. Marr. Occasional Paper 37. Institute of Arctic and Alpine Research, Boulder, Colorado.

KRUCKEBERG, A. R., AND D. RABINOWITZ. Biological aspects of endemism in higher plants. Unpublished manuscript.

NEELY, E. E. 1985. West Hoosier *Braya* preserve, Colorado, stewardship plan. The Nature Conservancy, Denver, Colorado.

O'KANE, S. L. 1986. Plant species of special concern in Colorado. Report prepared for Colorado Natural Areas Program, Department of Natural Resources, Denver, Colorado.

ROLLINS, R. C. 1953. *Braya* in Colorado. Rhodora 55: 109–116.

RYAN, T. A., B. L. JOINER, AND B. F. RYAN. 1982. Minitab reference manual. Pennsylvania State University, University Park.

SOKAL, R. R., AND J. F. ROHLF, 1981. Biometry, 2d. ed., W. H. Freeman Co., San Francisco.

STEBBINS, G. L. 1980. Rarity of plant species: a synthetic viewpoint. Rhodora 82: 77–86.

TWETO, O. 1974. Geologic map of the Mt. Lincoln 15-minute quadrangle, Eagle, Lake, Park and Summit counties, Colorado. USGS Misc. Field Stud., Map MF-556.

WHITSON, P. D., AND J. R. MASSEY. 1981. Information systems for use in studying the population status of threatened and endangered plants. Pages 217–236 *in* L. E. Morse and M. S. Henefin, eds., Rare plant conservation: geographical data organization. New York Botanical Garden, Bronx, New York.

ZAR, J. H. 1974. Biostatistical analysis. Prentice Hall, Englewood Cliffs, New Jersey. 620 pp.

BIOGEOGRAPHIC ASPECTS OF LEECHES, MOLLUSKS, AND AMPHIBIANS IN THE INTERMOUNTAIN REGION

Peter Hovingh[1]

Abstract.—Some biogeographical and paleobiological aspects of leeches, mollusks, and amphibians in the Intermountain Region are reviewed. Areas of eastern Nevada and western Bonneville Basin as well as the tristate region of Nevada, Utah, and Idaho are poorly inventoried with respect to many aquatic-dependent animals. Observations of *Batracobdella picta* in the Wasatch Mountains and *Erpobdella punctata* in Tule Valley in the Bonneville Basin extends the western ranges of these leeches in the Great Basin. Life history and size of leeches varies among the study sites in the northern hemisphere. Aquatic mollusk species have diminished greatly in both prehistoric and historic times, as demonstrated by Utah Lake where some 30 species once lived. Eight genera survived into historic times, and perhaps only one species presently lives there. Extinction of numerous mollusks in the Bonneville Basin is still unknown with respect to cause and time. The finding of the Western Spotted Frog (*Rana pretiosa*) in Tule Valley reveals both a different habitat for this species when compared to other study sites and that this species must have occupied the region during Lake Bonneville times. With the exception of the Leopard Frog (*Rana pipiens*), most other amphibians probably migrated into the Bonneville Basin after the desiccation of Lake Bonneville.

For eight years I have examined many ponds and springs to determine the distribution of amphibians and their breeding habitat requirements in such rather diverse arid regions as the Bonneville Basin and the Colorado Plateau as well as the regions of high precipitation, such as the Wasatch and Uinta mountains. It soon became apparent that, with the exception of the threatened and endangered species, very little systematic work had been done on the distribution of native aquatic species in the Intermountain Region. Most of the work was done before 1940. Today, with more and better roads and a very extensive inventory of the water resources, it seemed that new attempts should be made, especially in view of the recent efforts in understanding the hydrological basins and their paleo-history.

This paper reviews certain aspects of leeches, mollusks, and amphibians with the idea that with more information one might better understand their present distribution as well as their past distribution during the era of glaciers and the pluvial lakes. This paper is divided into three separate sections: (1) biogeographical distribution and life history variations of leeches, (2) review of mollusks in the Bonneville Basin, and (3) notes on the distribution of amphibians in Utah and Nevada.

Leeches

With the exception of Herrmann's work (1970) in Colorado, neither Nevada nor Utah have been methodically investigated for leeches. Twenty-one species were identified from Colorado (Klemm 1982, Herrmann 1970). Ten of these occur in western Colorado in the Middle Rocky Mountain Province and the Colorado Plateau Province (Herrmann 1970). Eight of these western Colorado species were found in Utah (Beck 1954, Barnes and Toole 1981) and four of them were found in Nevada (Klemm 1982). Table 1 lists the distribution. Note the lack of Erpobdellidae in Nevada.

Observations of *Placobdella ornata* (Verrill 1872) in western Colorado, *P. multilineata* (Moore 1953) in the Uinta Basin of Utah, and *P. parasitica* (Say 1824) in Nevada need further clarification. Only in Nevada (Truckee River drainage) does the turtle host exist within this region. *Theromyzon rude* (Baird 1869) was found in both Nevada and Colorado and should be found in Utah. The above leeches will not be discussed further.

Batracobdella picta (Verrill 1872) was reported from Current Creek, Wasatch County, Utah at 1,980 m elevation in a bog (Beck 1954). I found this leech very numerous on larval salamanders of *Ambystoma tigrinum* in

[1]Department of Biochemistry, University of Utah, Salt Lake City, Utah. Correspondence should be sent to 721 Second Avenue, Salt Lake City, Utah 84103.

TABLE 1. Distribution of leeches in the Intermountain Region.

Species	Western Colorado	Utah	Nevada
Glossiphoniidae			
Batracobdella picta (Verrill, 1872)	+	+	
Glossiphonia complanata (Linnaeus, 1758)	+	+	+
Helobdella stagnalis (Linnaeus, 1758)	+	+	+
Placobdella ornata (Verrill, 1872)	+		
Placobdella multilineata (Moore, 1953)		?	
Placobdella parasitica (Say, 1824)			+
Theromyzon rude (Baird, 1859)	+		+
Hirudinidae			
Haemopis marmorata (Say, 1824)	+	+	+
Erpobdellidae			
Dina dubia (Moore and Meyer, 1951)	+	+	
Dina parva (Moore, 1912)	+	+	
Erpobdella punctata (Leidy, 1870)	+	+	
Nephelopsis obscura (Verrill, 1872)	+	+	

Dog Lake (2,660 m elevation, Salt Lake County) and on breeding adults and larval salamanders in Red Pine Lake (2,680 m elevation, Summit County, Weber River drainage) in the Wasatch Mountains. These two observations extend the range of *B. picta* into the Great Basin. This leech was not found in 10 other salamander-inhabited ponds in the Wasatch Mountains (Provo, Weber, and Jordan River drainages) and two ponds of the Uinta Mountains (upper Duchesne River drainage). It was found between 2,062 and 3,224 m elevation in Colorado in 6 lentic water sources (Herrmann, 1970). The scattered distribution of *B. picta* could reflect both the distribution of the amphibian host as well as past mountain glacier distribution.

Glossiphonia complanata (Linnaeus 1758) was found in the bench region of Utah County and at Deer Creek Dam in Wasatch County (Beck 1954). Beck (1954) found *G. complanata* and *Helobdella stagnalis* (Linnaeus 1758) in the "same general distribution of quiet pools of water or slowly moving shallow streams". *Glossiphonia complanata* was found up to 3,610 m elevation in Colorado (Herrmann 1970).

Helobdella stagnalis (Linnaeus 1758) was found in a stream near Laketown (Bear Lake), Utah, the bench region of Utah County, and in Utah Lake (Beck 1954, Tillman and Barnes 1973). In Colorado *H. stagnalis* was found between 1,000 and 3,200 m elevation (Herrmann 1970). I found it feeding on *Nephelopsis obscura* (Verrill 1872) in the mountain ponds of the Uinta Mountains (upper Duchesne River drainage, elevation 3,060 m).

Tillman and Barnes (1973) showed that individual *Helobdella stagnalis* (Linnaeus 1758) produced two broods of young during May and June in Utah Lake. This variation in life history is different from those studied in Canada (Davies and Reynoldson 1976) and the British Isles (Murphy and Learner 1982) (Fig. 1). At these latter locations, the adults died after producing young; in some locations two generations per year occurred and in other locations only one generation per year occurred. Water temperature may be a determinant of the two life history patterns in Canada (Davies and Reynoldson 1976). It is unknown what the determinants of *H. stagnalis* life history in Utah Lake are, or if this life history variation is limited to Utah Lake.

Nephelopsis obscura (Verrill 1872) is perhaps the most common leech in Uinta Mountain ponds and may be the top predator in the ponds that do not contain salamanders. In the Uinta Mountain ponds, I observed *N. obscura* at night with densities of four to six leeches per m^2 of surface water in a pond that was at the most 1 m deep. Daytime observations were common in June and July, with densities less than one leech per m^2 and rare in September. Cocoons were deposited from early June to autumn, with the prevalent deposition occurring during late July. Growth patterns show, in late June, sizes between 0.01 and 0.85 g, with a group between 0.2 and 0.3 g (Fig. 2). During July, the large individuals

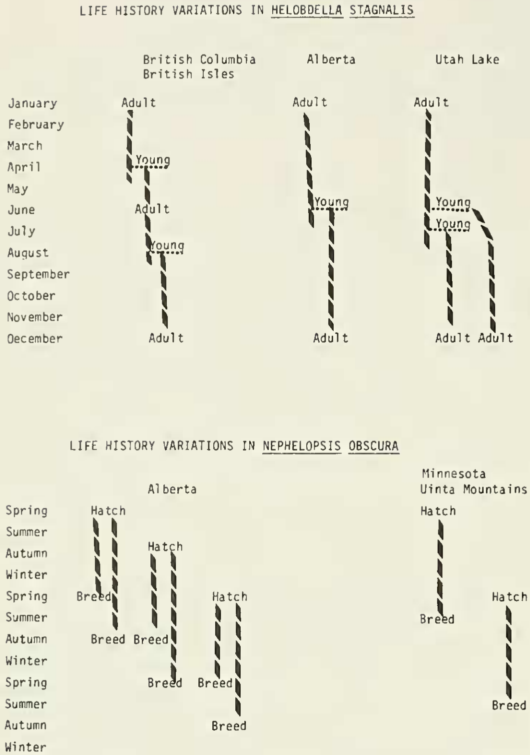

Fig. 1. Life history patterns of *Helobdella stagnalis* in British Columbia and Alberta (Davies and Reynoldson 1976), British Isles (Murphy and Learner 1982), and Utah Lake, Utah (Tillman and Barnes 1973) (upper figure). Life history patterns of *Nephelopsis obscura* in Alberta (Davies and Everett 1977), Minnesota (Peterson 1983), and the Uinta Mountains, Utah (based on size alone) (lower figure).

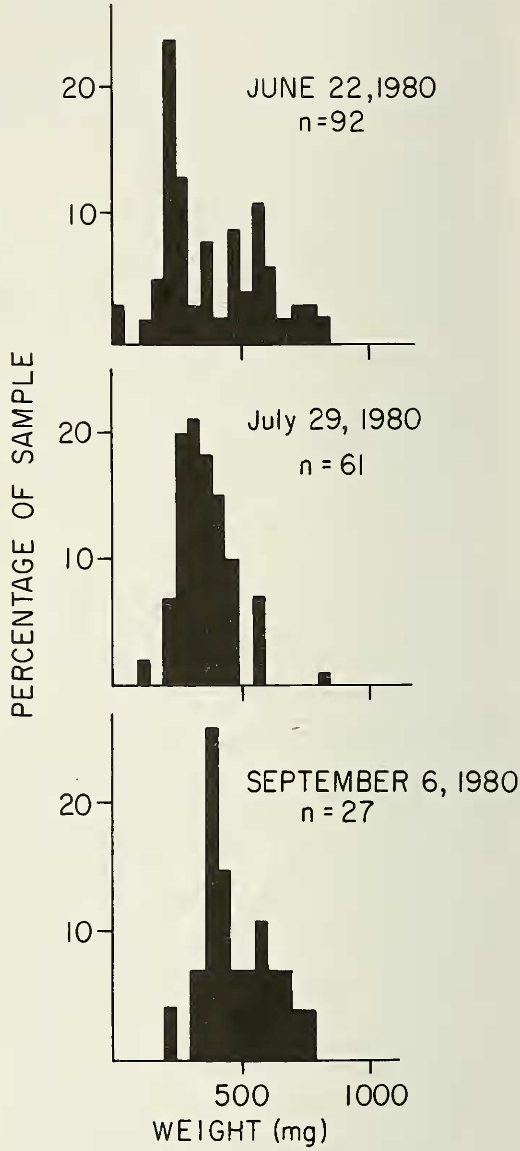

Fig. 2. Weights of *Nephelopsis obscura* in a Uinta Mountain pond during the summer. The leeches were weighed to the nearest 10 mg. For comparison, consult with Davies and Everett (1977) and Peterson (1983).

(larger than 0.5 g) die and can be seen in the bottom of the ponds. Growth continues to September. These data indicate that there is only one generation of young each year. One generation of young each year is similar to populations in Minnesota (Peterson 1983) and contrasts with the two-generation strategy in Alberta (Davies and Everett 1977) (Fig. 1). Sizes of leeches may not be an appropriate indicator of generation (Collins and Hohmstrand 1984a, b). *Nephelopsis obscura* reaches sizes of up to 1.2 g in the Uinta Mountains compared with populations in Alberta (0.41 g) and Minnesota (over 4.0 g) (Davies and Everett 1977, Collins and Hohmstrand 1984). The scarceness of leeches less than 0.1 g in the Uinta Mountain ponds contrasts sharply with the abundance of leeches in this class size in Alberta. It was found in the bench regions of Utah and Salt Lake counties in freely running streams or in shallow ponds (Beck 1954). It has not been recorded in Utah Lake. It was found only in lentic habitats in Colorado between 1,650 and 3,200 m elevation (Herrmann 1970) and only in lotic habitats in Michigan (Klemm 1972). Reynoldson and Davies (1980) noted that *N. obscura* was rather sensitive and intolerant to the changes in osmolarity of the aquatic medium.

Erpobdella punctata (Leidy 1870) was

found in the bench region of Utah County and at 1,740 m on Cove Mountain, Sevier County (Beck 1954). It has been found in Utah Lake (Barnes and Toole 1981). I found it in Red Pine Lake (2,680 m elevation, Weber drainage, Summit County) and in Solitude Lake (2,740 m elevation, Big Cottonwood Creek drainage, Salt Lake County) in the Wasatch Mountains and in five springs-wetlands in Tule (White) Valley (elevation 1,350 m, Millard County). The aquatic systems in Tule Valley have been isolated from other Bonneville Basin aquatic systems for some 13,000 years. In Tule Valley the specific conductance of the inhabited waters varied between 1,200 and 2,500 umhos/cm at 25 C, depending on the location in each wetland as well as the time of the year. Reynoldson and Davies (1980) noted that *E. punctata* was much more tolerant to variations in osmolarity than *Nephelopsis obscura* (Verrill 1872). Such tolerance might explain the presence of *E. punctata* in the interior of the Bonneville Basin, where it may exist as a relict species. Herrmann (1970) found *E. punctata* in both lentic and lotic habitats between 1,044 and 3,232 m elevation in Colorado. The leech was found in waters with pH variations of 6.3 to 10.3 (Herrmann 1970) and as low as pH 5.0 in Michigan (Klemm 1972). Davies et al. (1977) noted variations in life history patterns with *E. punctata* populations in Alberta and that the differences might be explained by interspecific competition with *N. obscura*.

Two other Erpobdellidae, *Dina dubia* (Moore and Meyer 1951) and *D. parva* (Moore 1912), have been reported from Utah. *Dina dubia* was found in association with *Nepholopsis obscura* (Verrill 1872) in lotic habitats in the bench region of Utah County (Beck 1954). *Dina parva* was found in Utah Lake (Barnes and Toole 1982).

Haemopis marmorata (Say 1824) was found in the bench region of Utah County, eastern slope of the Aquarius Plateau in Garfield County, and at Deer Creek Dam in Wasatch County (Beck 1954). It was found to tolerate the greatest total dissolved solids (2,807 mg/l) of all the other leeches and was found between 1,044 and 2,975 m elevation in Colorado (Herrmann 1970).

In the Colorado mountains, Pennak (1968) described the semidrainage lakes. In these lakes certain fauna and flora form a characteristic assemblage. The tiger salamander (*Ambystoma tigrinum*) and the yellow pond lily (*Nuphar polysepalum*) are the characteristic animal and plant. *Glossiphonia complanata*, *Nephelopsis obscura*, and *Helobdella stagnalis* occur together in these lakes (Pennak 1968). Other leeches found in semidrainage lakes include *Batracobdella picta*, *Batracobdella phalera*, *Dina dubia*, *Erpobdella punctata*, *Haemopis marmorata*, *Haemopis kingi*, and *Theromyson rude* (Herrmann 1970). The semidrainage ponds in the Uinta Mountains occur with the tiger salamander, yellow pond lily, *N. obscura*, and *H. stagnalis*. It would be interesting to study these ponds over the entire Uinta Mountains to determine how these ponds relate to the Colorado semidrainage ponds. During the glaciation some 25,000 years ago, all of these ponds and lakes were under ice fields and, thus, the ecology of the Uinta Mountain ponds and lakes may have evolved separately from the Colorado Rocky Mountain ponds and lakes.

Mollusks

Of some 100 species of mollusks in the Great Basin, some 50 species are found along the Highway 89-91 axis from Idaho to Arizona. With only Fish Springs National Wildlife Refuge being extensively inventoried in the western Bonneville Basin, much of the Bonneville Basin and eastern Nevada are still very fertile areas for studying the assemblage of molluscan species.

The desiccation of the pluvial lakes left many "semifossils," a name coined by early collectors who gathered empty shells from arid regions in the Bonneville Basin (Call 1884). Other collectors gathered shells from aquatic regions such as Utah Lake and Bear Lake and noted that they were fresh. In reviewing the literature it is difficult to know what specimens were found living. Many molluscan species require the examination of the soft parts for identification, and soft parts were not collected.

A major problem today is to determine what mollusks were present in the region before Lake Bonneville, the distribution of mollusks with the rising and desiccating waters of Lake Bonneville, and the present distribution of mollusks in the numerous basins of the Bonneville Basin and adjacent basins of Nevada. This information could tell us very much about the evolution of the present-day aquatic flora and fauna of the water sources in the numerous basins.

Both Utah Lake and Bear Lake have an abundant record of mollusks. Some 30 species of mollusks have been identified from Utah Lake environs. The taxa and their references are:

Unionidae: *Anodonta oregonensis* Lea 1838 (Chamberlin and Jones 1929, Jones 1940a), *Anodonta nuttalliana* Lea 1838 (Call 1884, Chamberlin and Jones 1929, Henderson 1931, Jones 1940a), *Anodonta wahlametensis* Lea 1838 (Chamberlin and Jones 1929, Jones 1940a).

Sphaeriidae: *Sphaerium pilsbryanum* Sterki 1909 (Baily and Baily 1951–1952, Call 1884, Chamberlin and Jones 1929, Jones 1940a), *Pisidium compressum* Prime 1851 (Baily and Baily 1951–1952, Call 1884, Chamberlin and Jones 1929, Jones 1940a), *Pisidium casertanum* Poli 1791 (Baily and Baily 1951–1952, Jones 1940a). *Pisidium variabile* Prime 1851 (Jones 1940a).

Valvatidae: *Valvata humeralis* Say 1829 (Baily and Baily 1951–1952, Chamberlin and Jones 1929), *Valvata utahensis* Call 1884 (Baily and Baily 1951–1952, Bickel 1977, Call 1884, Chamberlin and Jones 1929, Taylor 1966, Jones 1940a).

Hydrobiidae: *Fluminicola fusca* Haldeman 1847 (Baily and Baily 1951–1952, Call 1884, Chamberlin and Jones 1929, Jones 1940a), *Fluminicola seminalis* Hinds 1842 (Jones 1940a), *Amnicola limosa* Say 1817 (Baily and Baily 1951–1952, Chamberlin and Jones 1929, Henderson 1931, Jones 1940a), *Fontelicella (Paludestrina) longinqua* Gould 1855 (Jones 1940a), and *Tyonia (Paludestrina) protea* Gould 1855 (Jones 1940a).

Lymnaeidae: *Lymnaea stagnalis* Say 1821 (Call 1884, Chamberlin and Jones 1929), *Lymneus elodes* Say 1821 (Baily and Baily 1951–1952, Chamberlin and Jones 1929), *Fossaria modicella* Say 1825 (Chamberlin and Jones 1929, Jones 1940a), *Fossaria obrussa* Say 1825 (Chamberlin and Jones 1929, Jones 1940a), *Fossaria parva* Lea 1841 (Baily and Baily 1951–1952), *Stagnicola utahensis* Call 1884 (Baily and Baily 1951–1952, Bickel 1977, Chamberlin 1933, Chamberlin and Jones 1929, Jones 1940a), *Stagnicola caperata* Say 1929 (Baily and Baily 1951–1952), *Stagnicola proxima* Lea 1856 (Baily and Baily 1951–1952), and *Stagnicola hemphilla* Baker 1934 (Baily and Baily 1951–1952).

Physidae: *Physella propinqua triticea* Lea 1856 (Baily and Baily 1951–1952), *Physella utahensis* Clench 1925 (Baily and Baily 1951–1952, Barnes and Toole 1981, Bickel 1977, Chamberlin and Jones 1929, Jones 1940a).

Planorbidae: *Gyraulus similaris* Baker 1917 (Baily and Baily 1951–1952), *Gyraulus vermicularis* Gould 1847 (Chamberlin and Jones 1929, Jones 1940a), *Helisoma (Carinifex) newberryi* Lea 1858 (Baily and Baily 1951–1952, Call 1884, Chamberlin and Jones 1929, Taylor 1966, Jones 1940a), *Promenetus (Menetus) exacuous* Say 1821 (Baily and Baily 1951–1952, Chamberlin and Jones 1929), and *Planorbella (Helisoma) trivolvis* Say 1817 (Chamberlin and Jones 1929, Jones 1940a).

Ancylidae: *Ferrissia fragilis* Tryon 1863 (Baily and Baily 1951–1952), and *Ferrissia rivularis* Say 1817 (Chamberlin and Jones 1929).

Of these mollusks in Utah Lake only *Anodonta* (Henderson 1931), *Pisidium compressum* (Call 1884), *Physella propinqua triticea* (Baily and Baily 1951–1952), *Physella utahensis* (Barnes and Toole 1981, Bickel 1977), *Helisoma newberryi* (Center for Health and Environmental Studies 1975, Call 1884), *Fluminicola fusca* (Call 1884), *Valvata utahensis* (Call 1884), *Lymnaea stagnalis* (Call 1884), and *Stagnicola utahensis* (Chamberlin 1933) have been found living in Utah Lake. Presently *Physella utahensis* may be the only living species in Utah Lake (Barnes and Toole 1981).

The extinction of mollusks at Utah Lake and Bear Lake raises some questions. Was there a general extinction of mollusks in the Great Basin lakes during some specific period, or did each species become extinct with species specific causes and with lake specific causes? Did the rising waters of the prehistoric pluvial lakes cause any extinction of mollusks in the lakes and isolated springs, or did the rising waters distribute the isolated mollusks throughout the basin? Has there been any postpluvial evolution of mollusks?

The Bear Lake molluscan assemblage showed that *Helisoma newberryi* (the most common gastropod) was radiodated at 8270 B.P. (from 1.2 m deep at the Willis Ranch terrace, elevation 1,814 m), 7700 B.P. (0.3 m deep at the Lifton bar shoreline, elevation, 1,808 m), and 7880 B.P. (less than 1 m above Bear Lake shoreline, 1,806 m elevation) (Williams et al. 1962). These dates indicate that *H. newberryi* became extinct at a rather specific time and perhaps its extinction was related to the lowering of Bear Lake (Williams et al. 1962). A second report listed the age of *H. newberryi* and *Sphaerium* sp. at the Bear Lake shoreline at 12,000 B.P. (Smart 1963). This would suggest that the extinction of mollusks at Bear Lake included an assemblage of species. Unfortunately, the dates are in conflict (fictitious results can result under several circumstances, see Keith and Anderson 1963, Riggs 1984, Rubin and Taylor 1963). It would be important to reexamine the ages of mollusks of Bear Lake and to examine the ages of mollusks at Utah Lake and other lakes in the Great Basin.

Whereas many molluscan species have limited present-day distribution, some of these species may have a widespread fossil distribution. *Stagnicola pilsbryi* Hemphill, 1890, is an exception, with its distribution being limited to Fish Springs National Wildlife Refuge and having no fossil record (Russell 1971, Taylor et al. 1963). Presently *S. pilsbryi* is considered extinct. It is unknown if *S. pilsbryi* evolved at Fish Springs after the desiccation of Lake Bonneville (Russell 1971).

More studies of molluscan biogeographic distribution and habitat requirements in the Intermountain Region are needed to understand the evolution of the aquatic systems in the Great Basin (Yen 1951, Taylor et al. 1963, Taylor 1960, Russell 1971, Murray 1970).

AMPHIBIANS

Fourteen species of amphibians occur in Nevada and in Utah, with 12 species common to both states (Linsdale 1940, Banta 1965, La Rivers 1942, Tanner 1931). Most of these amphibians can be placed into one of two groups. The first group is postulated as arriving into the Intermountain Region from the south and is largely confined to the Colorado River drainage in Utah and Nevada (Tanner 1978). These species include *Bufo cognatus*, *B. microscaphus*, *B. punctatus*, *B. woodhousei*, *Hyla arenicolor*, *Rana onca*, and *R. fisheri*. *R. onca* and *R. fisheri* may be part of the *Rana pipiens* "complex."

Bufo woodhousei is the only amphibian arriving from the south that penetrates into the Bonnevillle Basin and extends along the axis of Interstate 15 to and including portions of the Snake River drainage of Idaho. In the Bonneville Basin, *B. woodhousei* is found in the Sevier River drainage and in the isolated Snake Valley Basin in western Utah (Tanner 1931). Another species, *Scaphiopus intermontanus* also came from the south because there was not much suitable habitat during the pluvial times for this amphibian to breed (Hovingh et al. 1985). *Scaphiopus intermontanus* is not dependent upon water for migration as is the other species in the first group.

The second group is postulated as arriving from the north, from the east, or from the west. This second group includes *Ambystoma tigrinum*, *Hyla regilla*, *Pseudacris triseriata*, *Bufo boreas*, *Rana pretiosa*, and *R. pipiens*. If one were to ask if any amphibians occurred in the Intermountain Region during the pluvial and glacial era some 25,000 years ago, this second group would have the most likely candidates. The Leopard Frog (*R. pipiens*), being found in many isolated springs throughout the Bonneville Basin and in numerous basins of Nevada, in mountainous habitat, and adapting to flood plains of the White River (Uintah County), is one species that most likely occupied the region during the pluvial times.

The Western Toad (*Bufo boreas*) largely inhabits the northwest United States and occupies areas in northern Nevada and the mountain regions of Utah. There are some recognized subspecies in central and southern Nevada (Linsdale 1940). The Western Toad has not been found along the Utah-Nevada border (in particular, the Snake and Spring valleys). This toad breeds in the valley floors in Nevada and up to 3,050 m elevation in the mountains of Utah. When the species breeds in the valley floors of Utah, there may be some site competition with *B. woodhousei*. It seems that if the Western Toad occupied the Bonneville Basin during the pluvial times, it would presently occupy the valleys of the Utah-Nevada border.

The Tiger Salamander (*Ambystoma tigrinum*) and the Chorus Frog (*Pseudacris triseriata*) are very common in the aquatic systems of the Uinta Mountains in regions that formerly were occupied by glaciers. The Tiger Salamander is also common in the ponds and reservoirs along the Wasatch Front and in the Wasatch Mountain lakes (Tanner 1931). The Chorus Frog is less abundant along the lower elevations of the Wasatch Front (Tanner 1931) and is scarce in the high mountain lakes of the Central Wasatch Mountains. Neither species has been collected in Nevada, although the salamander is found in both the Raft River and Pine Valley mountains. It would seem that if the Tiger Salamander and Chorus Frog were present during Lake Bonneville times, their distribution would occur in regions of eastern Nevada and western Bonneville Basin (Spring and Snake valleys). Their limited distribution might be explained by (1) relict populations during the pluvial times with no opportunity for extending their range into the Bonneville Basin, or (2) migration into Utah in postpluvial and postglacial times along the Uinta Mountains and fanning out via the Wasatch Mountains to the Pine Valley Mountains in the south and the Raft River Mountains in the north. In the cases of the Tiger Salamander and the Chorus Frog (two eastern amphibians), one could postulate that between Lake Bonneville and the alpine glaciers there was not any habitat for these amphibians.

The Pacific Treefrog (*Hyla regilla*) is common in California and Oregon and in isolated populations in both the Colorado River drainage of Nevada and southwestern Utah, in central Nevada, and in the Raft River Mountains of Utah (Tanner 1931, Reynolds and Stephens 1984). This particular frog may have extended its range eastward during the pluvial times and now in the postpluvial era remains in isolated pockets.

The Western Spotted Frog (*Rana pretiosa*) occurs in many relict populations from near Juneau, Alaska, southward throughout Washington, Oregon, British Columbia, Idaho, western Montana, the upper Humboldt River drainage in Nevada, Yellowstone National Park, and the Big Horn Mountains in Wyoming and in isolated pockets of the Bonneville Basin and drainage system in Utah (Dunlap 1977, Turner and Dumas 1972, Morris and Tanner 1967, Tanner 1931). The museum records of the University of California (Berkeley), Brigham Young University (Provo), University of Utah (Salt Lake City), and the University of Michigan (Ann Arbor) show the distribution in Utah to include the Snake Valley and Deep Creek drainage in the western Bonneville Basin and the Mono Lake (Juab County), the San Pitch River (a tributary of the Sevier River), and numerous locations in Salt Lake, Utah, Summit, and Wasatch counties in the eastern Bonneville Basin. Western Spotted Frogs have not been found in the drainage of Thousand Springs Creek in northeastern Nevada and northwestern Utah, in the Raft River Mountain region, and in the main Sevier River drainage. Thus, from the records, the distribution of the Western Spotted Frog in the Bonneville Basin is several isolated populations.

In 1980 I found the Western Spotted Frog in Tule (White) Valley in Millard County, Utah. Tule Valley lies between Snake Valley on the west and the Sevier drainage basin on the east. Tule Valley has been isolated from the Lake Bonneville aquatic system for 14,000 years, and highly aquatic species such as the Western Spotted Frog could only occur in Tule Valley if it also occurred in the Lake Bonneville environs (assuming no human intervention). Thus, one may assume that the Western Spotted Frog along with the Leopard Frog occupied the Bonneville Basin at the time of Lake Bonneville.

In examining the Tule Valley populations, one finds the Western Spotted Frog has adapted to a more saline environment than that found in other parts of its distribution. The wetlands lie between 1,347 and 1,350 m elevation on the valley floor, and most have warm water sources (25-19 C). The total dissolved solids varies in the springs from 1,000 to 1,400 mg/l (Stephens 1977) and the specific conductance varies between 1,000 and 3,000 umhos/cm at 25 C, depending on the location in the wetlands and the time of year. In Tule Valley, the Western Spotted Frog breeds in the cold water portion (the most distal from the spring source) of the warm water springs.

Although amphibians are considered terrestrial animals, the arid regions often limit populations from extending their ranges. The distribution of these amphibians may be very local, endemic, and relict as are the Tule Valley populations of the Western Spotted Frogs. The distribution of amphibians in the Intermountain Region can readily be the result of the pluvial and glacial eras and the subsequent desiccation. However, one must presently be careful in noting the presence or